

**DETAILS RELATING TO THE INVENTORS**

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TITLE OF THE INVENTION:

SERVO-ASSISTED BUTTERFLY VALVE FOR AN INTERNAL COMBUSTION ENGINE PROVIDED WITH AN ADJUSTMENT SYSTEM FOR THE LIMP-HOME POSITION

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The present invention relates to a servo-assisted butterfly valve for an internal combustion engine provided with an adjustment system for the limp-home position.

10        BACKGROUND OF THE INVENTION

In an internal combustion engine, the function of a butterfly valve is to regulate the flow of fresh air supplied to the cylinders; normally, a butterfly valve has a valve body housing a valve seat engaged by a butterfly body which is keyed on a shaft in order to rotate between an open and a closed position of the valve seat under the action of an electric actuator coupled to this shaft by means of a gear transmission. An elastic body (typically formed by a double spring) is also coupled to the shaft and exerts a torque on the shaft which tends to rotate the butterfly body towards the open position and which, in the absence of action by the electric actuator, causes the butterfly body to be disposed in a partially open position (commonly known as the limp-home position) as a result of the presence of an abutment surface which forms an abutment for the elastic

body against which the opening movement caused by this elastic body is stopped.

Currently, the abutment surface is formed by a support body which is obtained by casting on the crude 5 valve body; however, the sum of the tolerances in respect of the casting work, the joint molding of the shaft, the diameter of the butterfly body and the diameter of the valve seat cause a total air flow dispersion in the limp-home position of approximately  $\pm 18-20\%$ . In some 10 applications, this total air flow dispersion value in the limp-home position is too high; it has therefore been proposed to carry out precision machining of the support body, which precision machining makes it possible to reduce the total air flow dispersion in the limp-home 15 position to approximately  $\pm 10-12\%$ .

However, this precision machining is particularly costly and in any case does not make it possible to obtain a total air flow dispersion value in the limp-home position of less than  $\pm 10\%$ . Moreover, in order 20 significantly to vary the value of the air flow in the limp-home position (typically to be able to adapt the butterfly valve to different types of engine) it is necessary to modify the casting mould to vary the position of the support body; in general, a specific 25 valve body and therefore a specific mould is required for each flow value, which obviously increases production

costs.

In order to try further to reduce the total air flow dispersion value in the limp-home position, it has been proposed to replace the support body with a screw which 5 is screwed through the valve body and has a head disposed outside this valve body and a free end forming the abutment surface against which the elastic body comes to abut. During the production stage, each butterfly valve is disposed on a test bench, where the value of the air 10 flow in the limp-home position is measured in real time; in these circumstances, the axial position of the screw is adjusted by screwing or unscrewing the screw with respect to the valve body until the desired value of the air flow in the limp-home position is accurately 15 obtained. Preferably, once the axial position of the screw has been adjusted, the screw is locked with respect to the valve body to prevent any subsequent displacement (typically as a result of the vibrations generated by the operation of the engine).

20 The use of a through screw does not make it possible, however, significantly to vary the air flow value in the limp-home position without modifying the casting mould.

FR2781525 discloses a motorized throttle butterfly 25 with limp-home facility for use in motor vehicles and having a spring with two torsion zones on either side of

bolt to set throttle in limp-home position; the first zone has its end connected to the throttle housing, and the second zone has its end coupled to a support fixed to the butterfly spindle. The two spring zones are on either 5 side of a bolt that when engaged sets the throttle in the limp-home position.

EP1148225 discloses a throttle return mechanism for an electronically controlled throttle that provides for the precise setting of a limp home throttle blade 10 position. The throttle return mechanism includes a return spring with two legs attached to a fixed shaft, and a bracket, which is attached to a drive mechanism and includes stops that engage the return spring as the bracket rotates about the fixed shaft; each stop is cam 15 shaped and rotatable to provide for adjustment of the limp home throttle blade setting. When the drive mechanism is disabled the legs of the return spring will engage the stops on the bracket and rotate the throttle blade to the limp home position; the second leg of the 20 return spring will rotate and hold the throttle valve in a limp home throttle position to allow a driver to maneuver the motor vehicle.

#### SUMMARY OF THE INVENTION

The object of the present invention is to provide a 25 servo-assisted butterfly valve for an internal combustion engine provided with an adjustment system for the limp-  
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home position, which is free from the above-described drawbacks and which is easy and economic to produce.

The present invention therefore relates to a servo-assisted butterfly valve for an internal combustion engine provided with an adjustment system for the limp-home position as set out in claim 1.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the accompanying drawings, which show a non-limiting embodiment thereof, and in which:

Fig. 1 is a front, diagrammatic view, with some parts removed for clarity, of a servo-assisted butterfly valve for an internal combustion engine of the present invention;

Fig. 2 is a perspective, exploded view of a detail of Fig. 1; and

Fig. 3 is a side view, in cross-section and on an enlarged scale, of a further detail of Fig. 1.

DETAILED DESCRIPTION OF THE INVENTION

In Fig. 1, a servo-assisted butterfly valve for an internal combustion engine is shown overall by 1; the butterfly valve 1 comprises a valve body 2 which houses an electric actuator 3, a cylindrical valve seat 4 and a butterfly body 5 (shown in Fig. 2) which engages the valve seat 4 and moves between an open position and a closed position of this valve seat 4 under the action of

the electric actuator 3. The butterfly body 5 is keyed on a metal shaft 6 which is mounted on the valve body 2 in order to rotate about a longitudinal axis 7 as a result of the action of the electric actuator 3 in order to 5 displace the butterfly body 5 between the above-mentioned open and closed positions of the valve seat 4.

The electric actuator 3 is mounted on a metal plate 8 provided with a pair of through holes 9 via which two electrical conductors 10, supplying electrical energy to 10 the electric actuator 3, pass; a respective insulating bushing 11 is interposed between each electrical conductor 10 and the respective hole 9 of the plate 8. The main function of the plate 8 is to enable the electric actuator 3 to be secured to the valve body 2; 15 for this purpose, the plate 8 has three drilled radial projections 12 via which respective screws 13 for fastening to the valve body 2 are inserted.

The electric actuator 3 transmits movement to the shaft 6 via a gear transmission 14 which comprises a 20 toothed wheel 15 keyed on the shaft 16 of the electric actuator 3, a toothed wheel 17 keyed on the shaft 6, and an idle toothed wheel 18 interposed between the toothed wheel 15 and the toothed wheel 17. The toothed wheel 17 has a solid central cylindrical body 19 which is keyed on 25 the shaft 6 and is provided with a circular crown portion 20 which has a series of teeth coupled to the toothed

wheel 18. The toothed wheel 18 has a first series of teeth 21 coupled to the toothed wheel 15 and a second series of teeth 22 coupled to the toothed wheel 17; the diameter of the first series of teeth 21 is different 5 from the diameter of the second series of teeth 22 and therefore the toothed wheel 18 has a non-unitary transmission ratio. Normally, the toothed wheel 17 and the toothed wheel 18 are made from plastic material, while the toothed wheel 15 is made from metal material.

10 As shown in Fig. 2, a double spring 23 is coupled to the shaft 6 and has a front spring 24 provided with a first projection 25 coupled mechanically to the toothed wheel 17 (and therefore to the shaft 6) and a rear spring 26 provided with a projection 27 coupled mechanically to 15 the valve body 2. The front spring 24 and the rear spring 26 are connected together by a curved member 28 which, in operation, is normally in abutment on an abutment body 29.

The front spring 24 tends to rotate the shaft 6 in 20 the clockwise direction with a movement which tends to bring the butterfly body 5 into the above-mentioned closed position, while the rear spring 26 tends to rotate the shaft 6 in the anti-clockwise direction with a movement which tends to bring the butterfly body 5 into 25 the above-mentioned open position; the front spring 24 generates an elastic torque lower than the elastic torque

generated by the rear spring 26, with the result that, overall, the double spring 23 tends to rotate the shaft 6 in the anti-clockwise direction. The anti-clockwise rotation (i.e. towards the open position) of the shaft 6 5 under the action of the double spring 23 is blocked by the presence of the abutment body 29 which forms an abutment surface against which the curved member 28 comes to abut; in this way, in the absence of action by the electric actuator 3, the double spring 23 brings the 10 shaft 6 (and therefore the butterfly body 5) into a partially open or limp-home position.

When the electric actuator 3 is actuated, the drive torque generated by this electric actuator 3 on its shaft 16 is adapted to rotate the shaft 6 (and therefore the 15 butterfly body 5) into the above-mentioned closed position against the elastic torque of the rear spring 26 and is adapted to rotate the shaft 6 (and therefore the butterfly body 5) into the above-mentioned open position against the elastic torque of the front spring 24.

20 As shown in Figs. 2 and 3, the abutment body 29 comprises a cylindrical pin 30 which is mounted to rotate about its own central axis 31 parallel to the axis 7; the cylindrical pin 30 in particular has a free front end 32 which can be engaged by an operator by means of a spanner 25 or screwdriver, and a rear end 33 opposite the front end 32 and inserted in a blind housing hole 34 so as to be

able to rotate with respect to this housing hole 34. Between the front end 32 and the rear end 33, the pin 30 is coupled to an eccentric member 35 which is eccentric with respect to the axis 31.

5 It will be appreciated that by rotating the pin 30, i.e. by rotating the abutment body 29, about the axis 31, the eccentric member 35 is caused to rotate thereby obtaining a variation of the position of the abutment surface against which the curved member 28 abuts; in this 10 way it is possible accurately to set the position of the abutment surface against which the curved member 28 abuts and therefore the flow of air in the limp-home position.

During the production stage, the butterfly valve 1 is disposed in a test bench (known and not shown) in 15 which the value of the air flow in the limp-home position is measured in real time; in these circumstances, the angular position of the abutment body 29 is adjusted by rotating the pin 30 about the axis 31 until the desired air flow value in the limp-home position is accurately 20 obtained. Preferably, once the angular position of the abutment body 29 has been set, the abutment body 29 is locked with respect to the valve body 2 to prevent any subsequent displacement (typically as a result of the vibrations generated by the operation of the engine).

25 The rear end 33 of the pin 30 comprises a knurled portion 36 which has a diameter slightly greater than the  
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diameter of the housing hole 34, and a smooth portion 37 which has a diameter substantially equal to the diameter of the housing hole 34. When the abutment body 29 is coupled to the valve body 2, only the smooth portion 37 5 of the rear end 33 of the pin 30 is inserted into the housing hole 34 so that the pin 30 can rotate with respect to the housing hole 34; in order permanently to lock the position of the pin 30 relative to the hole 2, the pin 30 is hammered so that the knurled portion 36 is 10 also driven into and locked in the housing hole 34.

The above-described use of the abutment body 29 comprising the eccentric member 35 enables a very fine adjustment of the air flow in the limp-home position and is very simple and economic to produce. Moreover, it is 15 very simple to obtain different air flow values in the limp-home position without in any way modifying the casting mould; in practice, it is enough to vary the position of the housing hole 34, which is produced by drilling the valve body 2 after this valve body has been 20 cast.

In summary, the above-described solution provides the following advantages: recovery of the dispersions resulting from the tolerances of the various components which play a part in defining the value of the air flow 25 in the limp-home position without the need to use precision machining, the possibility of readily obtaining

different air flow values in the limp-home position simply by moving the position of the housing hole 34 and a guarantee that the setting can be maintained in operation even in the case of thermal shocks or 5 vibrations as a result of the locking of the knurled portion 36 in the housing hole 34.